A Policy Scenario Analysis of Sustainable Agricultural Development

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A Case Study for Nepal

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Abstract

This paper aims to present an operational framework for sustainable agricultural development at the local or regional level. Sustainability targets are introduced by using critical threshold values for policy-relevant variables of different nature. The paper introduces then a so-called flag model to identify feasible and/or desirable policy scenarios. The approach is illustrated by means of an extensive case study on the Bagmati region in Nepal.

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1. The Challenge of Sustainable Agricultural Development

Agriculture has gone through intriguing cyclical movements in the past decades. In the late 1960s and early 1970s it was generally expected that agricultural production growth would not be able to keep pace with the rising needs for food by our world population. But as of the mid 1970s, world food production started to grow rapidly, thus reducing the threat of an ever increasing gap between supply and demand. Since the late 1980s however, the optimism was tempered because of the persistent problems of insufficient food supplies in major parts of our world and the environmental and social concerns on intensified farming methods. At present, there is an increasing recognition of the problem of food security in the medium and long term, inter alia as a result of depletion of natural resources and of environmental and land degradation (see United Nations 1997 for more details). Against these background observations, the notion of sustainable agricultural development is rapidly gaining importance (see also Lancker 1998, Nijkamp 1998).

The interest in sustainable agricultural development has risen rapidly after the United Nations Conference on Environment and Development in Rio de Janeiro (1992), as - in the spirit of the Brundtland Report (1987) - it was recognised that, as a consequence of the intensified use of natural resources and the rise in pollution world-wide, more serious attention was needed for environmental protection and sustainable development. In the action programme labelled 'Agenda 21' a vast array of policy proposals and plans has been laid down. The problem however, is that global recommendations need to be translated to the meso level of economic sectors and regions where different trade-offs may be made.

Consequently, the general description of sustainable development in the Brundtland Report (see WCED 1987) as a path that meets the need of the present without comprising the ability of future generations to meet their own needs is too abstract and too little committing to be of practical use for a balanced agricultural policy (see Nijkamp 1998). The Food and Agricultural Organisation (FAO) of the United Nations has tried to offer a more specific description of sustainable agricultural development as a development path in which resource use and environmental management are combined with increased and sustained production, secure livehoods, food security, equity, social stability and people's participation in the development process. If these conditions are fulfilled, sustainable agricultural development is environmentally non-degrading, technically appropriate, economically viable and socially acceptable, so that a maximum welfare can be achieved through a co-evolutionary strategy focussed on economic, environmental and social objectives and/or constraints on agricultural production, now and in the future (see also Pearce and Atkinson 1993).

Clearly, conflict management is at the heart of any sustainability policy (cf. Crane et al. 1996), as there are different interests among policy-makers, among various actors and stakeholders, among population groups affected, among different regions and even among different generations. In as far as sustainable development does not offer a normative framework for policy evaluation, it is evident that the empirical results of sustainability analysis are of a descriptive nature or at best of a 'what-if nature.

The present paper aims to offer a new methodological framework for sustainable development policy in the agricultural sector, by taking as a frame of reference the normative views of experts on critical thresholds or critical loads for the exceedance of sustainability indicators for a given agricultural sector in a given region (see also Nijkamp and Vreeker 1998; Brown et al. 1997). The expert information is based on scientific knowledge on the carrying capacity of the region concerned in regard to the agricultural sector and may comprise economic, biophysical and social variables.

Next, the information on these critical threshold values can be cast in the framework of a decision support model in which ranges of critical threshold values for sustainability analysis are specified, based on intrinsic uncertainty in the reliability and precision of expert information. For this purpose, a new multi-criteria decision support tool, i.e. the flag model, will be employed in order to guide the policy-making choice process in a user-friendly and manageable way. To illustrate the applicability and scientific potential of this new approach, a case study will be presented for the Bagmati region in Nepal. In this case study several agricultural policy scenarios will be described and analysed with a view to the identification of a development option for the area concerned that is fulfilling the sustainability conditions to a maximum extent. The paper will be concluded with some further reflections on decision support analysis for sustainable development.

2. Indicators for Sustainable Agricultural Development

Introduction

The major scientific challenge in any sustainability analysis is to develop an assessment framework that is able to offer an empirical test whether a certain state of the economy (e.g., a regional agricultural system) is sustainable or not (or whether a given state is more sustainable than another one). For this purpose it is necessary to (i) develop an indicator system through which sustainability can be measured, (ii) identify a set of normative reference values (critical threshold conditions) which may be used to check the exceedance of such critical values, and (iii) develop a decision support system that is able to guide the decision-making process by eliminating unfeasible choice options and identifying promising agricultural development options (cf. Hermanides and Nijkamp 1998; and Nardini 1997). The present section will mainly be devoted to the identification of indicators. The two remaining issues will be dealt with in the subsequent sections.

Rational and consistent policy analysis presupposes a reliable assessment and a balanced evaluation of all foreseeable relevant consequences of alternative courses of action (or choice possibilities). The question is of course, what has to be considered as a relevant impact. Sometimes, the answer to this question has to be found in *a priori* specified policy objectives, but is also happens frequently that the judgement of the relevance of a certain variable is the result of a learning process. In case of an evaluation of future choice options, also scenario experiments may then play an important role as a communication and learning-by-doing tool for policy-makers (see also Giaoutzi and Nijkamp 1993).

In any case there is a need to specify sustainability indicators which can be measured in a qualitative or quantitative sense, preferably with both a space and time co-ordinate (cf. Spooner et al. 1994). To some extent, indicators may be seen as pointers which, used effectively, may reveal conditions and trends that help in development planning and decision-making (cf. Tschirley 1996). Also, indicators can assess the performance of economic and ecological systems (and their change over time) and help set policy goals with regard to sustainable (agricultural) development. According to Nijkamp and Ouwersloot (1997) an indicator may be conceived of as a partial but representative mapping of a compound attribute of a phenomenon under study into a one-dimensional measure which has a relevance for policy-making. Sustainability indicators comprise economic, environmental and social variables in an integrated manner. To develop proper indicator systems, there is a need for an improvement of existing information and reporting systems, for a better integration of economic, ecological and social information, and for regular and reliable trend explorations. The latter observation is in agreement with the so-called B-S-E (biophysical, social, economic) classification of indicators for sustainable development (see Opschoor and Reijnders 199 1).

An alternative classification has been developed by the OECD (1993), by making a distinction into pressure, state and response indicators (so-called P-S-R indicators). Pressure indicators may comprise e.g. population growth or fertiliser use, state indicators may relate to e.g. soil pollution or nutrition level, and response indicators may concern e.g. emission reduction or biological agriculture.

Criteria for sustainability indicators

To use sustainability indicators as an effective tool, relevant indicators should be selected from many existing indicators: core indicators. A limited and manageable number of indicators creates a more useful tool than a large number of unselected indicators. In determining these relevant indicators, certain criteria should be considered:

(1) Indicators must cover the three dimensions of sustainability. Therefore an equal balance between biophysical, social and economic indicators is needed. Also, it is important to provide a certain integration between the selected indicators and the policy targets and objectives of a country.

(2) Sustainability indicators should be constructed on a spatial and temporal scale relevant to natural, social and economic phenomena. The spatial scale depends on the policy level of decision-making: global, regional or local. The temporal scale depends on the time scale of a certain study or research.

(3) Indicators should be quantifiable, which implies both measurability and the availability of data. Also, indicators should be legible and transparent. It is therefore important to select 'self-explanatory' indicators based on known concepts capable of making a complex reality intelligible.

(4) The sustainability indicators should be able to be used in forecasting and thus be descriptive (help describe a system's present or past conditions and developments), proscriptive (provide information on the future structure or behaviour of a variable or system based on the construction of scenarios or hypotheses) and predictive (as predictive indicators, but rather based on forming laws or principles).

(5) An another important criterion is the level of aggregation of information. The question of when to aggregate indicators is important in managing sustainability. Usually, indicators are considered part of an information pyramid going from detailed to local information to more aggregated information at the national or global level. Aggregation affects the quantity and quality of information that is passed along to decision-makers. When considering information, it is critical to determine whether its aggregation will have a significant effect on the decision-

making outcome (Bie et al. 1997, p.23). Henninger made a classification for indicator information, which refers to the different scales of information needed at diierent policy levels (Henninger 1992).

a. Indicators which can be obtained for many countries and require very little new data;
b. Indicators which can be obtained from countries with detailed natural resource database;
c. Indicators which are not available because of data limitations.

Core indicators

In order to operationalise indicators in decision-support systems, it is necessary to reduce the number of unmanageable indicators and assess a core set or working set of indicators. Many lists of indicators are only indicative and have to be operationalised for specific policy questions and geographical areas. A generally useful methodology for limiting the number of indicators, while nevertheless maintaining completeness and cohesion, is to use a hierarchical approach, based on a tree-like composition for aggregation and disaggregation of indicators, so that a distinction between single and composite indicators can be made (see Nijkamp and Ouwersloot 1997).

3. Use of Critical Threshold Values in Evaluating Sustainable Agricultural Development Options

In a recent study the so-called flag model has been developed as an operational tool for decision support (see Nijkamp 1998). The flag model presents a new approach to the analysis of spatial sustainability, with a particular view on agriculture. It has been developed to be able to evaluate scenarios and assess the degree of sustainability of various policy alternatives. The flag model is not designed to answer the question which scenario is the best. The choice for a future policy needs to be made by means of a final assessment.

The flag evaluation method uses sustainability indicators to calculate and evaluate scenarios. These indicators are divided into three classes: economic, social and biophysical indicators. For each indicator, a normative reference value - called a critical threshold value - is required: CTV. They provide a frame for evaluation of future policy scenarios and the input for the impact assessment of the flag model.

Although indicators can provide a lot of information by pointing out where the problems of policies are and can be very helpful in planning and decision-making, it must be noticed that indicators can never replace a good judgement and that they are no guarantee for sustainabiity. One indicator does not say anything about sustainability, unless a reference value like thresholds is given to it. To be able to determine the actual state of sustainability or future outcomes of scenarios, critical threshold values (CTVs) are needed. CTVs are values that cannot be exceeded without causing unacceptably high damage and risk to the environment (Nijkamp 1998).

To determine the actual state of a certain area, it is necessary to divide indicators into 'good and 'bad' indicators. Good indicators will have a positive influence on sustainable development if the value of the indicator increases. Bad indicators will have a negative influence on sustainable development, if the value of the bad indicator increases. An outcome of a bad sustainability indicator that is lower than a CTV is in principle desirable and more sustainable.

An entire set of CTVs can provide a reference system for judging actual states or future outcomes of scenario experiments (Nijkamp and Ouwersloot 1997). CTVs are based on specific characteristics like a specific country or area with its own natural, socio-economic and political conditions and problems. Therefore, CTVs are not always unambiguous. In certain areas and under certain circumstances different experts and decision-makers may have different views on the precise level of an acceptable CTV. A relatively simple and manageable approach to the above uncertainty problem is to introduce a band width for the corresponding value of the CTV, defined as a minimum CTV (CTVmin) and a maximum CTV (CTVmax). CTVmin indicates a conservative estimate of the maximum allowable threshold of the corresponding sustainability indicator (min-max condition). CTVmax on the other hand refers to the maximum allowable value of the sustainability beyond which an alarming development will occur (max-max condition) (Nijkamp 1998).

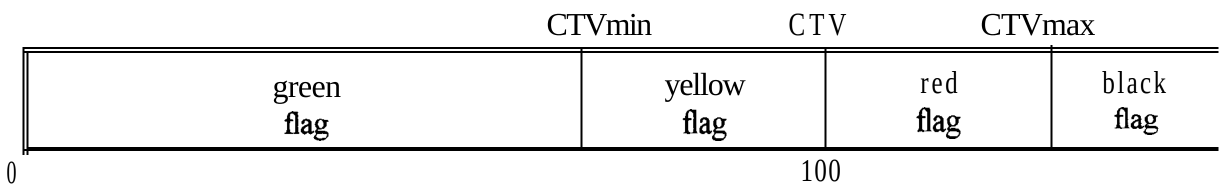

Figure 1. A range of CTV values (Nijkamp 1998)

The line segments can now be interpreted in the following imaginative way (Nijkamp 1998):

- 'green' flag: no reason for specific concern
- 'yellow' flag: be very alert
- 'red flag: reverse trends
- 'black' flag: stop further growth

The flag evaluation is based on the corresponding colours of the flags. A green flag is interpreted as sustainable, yellow as ambiguous but still sustainable, red as ambiguous but no longer sustainable and a black flag as certainly unsustainable. The evaluation outcomes of our empirical scenario analysis of Nepal is based on the presentation of such coloured flags.

By counting the frequency of various flags it is possible to eliminate less desirable options and to identify the stronger alternatives. By adding a weight system - standard in many multicriteria analyses - an unambiguous choice among the various courses of action may then be obtained.

It goes without saying that the above described approach to critical threshold values is still rather simplified. Clearly, in empirical policy situations at a detailed geographical scale much more refined information may be necessary in order to account for site-specific environmental conditions (cf. also Antoine et al. 1997). Interesting examples of more sophisticated methods for calculating and mapping critical thresholds for sulphur, nitrogen, acidification and eutrophication in Europe using Geographic Information Systems technology can be found in Hettelingh et al. (1995) and Posch et al. (1997). However, for most agricultural applications such GIS-based information is unavailable, so that by necessity some more global information on environmental carrying capacity has to be used. We will now move to our empirical work.

4. Sustainable Development Issues in the Bagmati Region in Nepal

Nepal

This section will offer an introduction to the scenario analysis for the Bagmati region in Nepal with regard to sustainable development in the agricultural sector. This part cuts a profile of Nepal and the agricultural sector in the Bagmati region and explains its constraints and bottlenecks.

Nepal is a landlocked country sited between China (Tibet) and India. It has almost 20 million citizens over 141,577 square kilometres and is densely populated. Nepal is located against the southern part of the high Himalayas, the worlds' highest mountainous area which makes it a very mountainous country. Nepal remains one of the poorest countries in the world, with a per capita income (GDP p.c.) of about $190 a year and a GDP growth of around 2.8 per cent (World Bank 1995, p.375). An estimated 7 to 8 million of the country's population live in conditions of absolute poverty as defined by minimum basic caloric intake (World Bank 1995, p.374). Nepal's population is growing rapidly at about 2.5 per cent a year, and the population density of around 600 persons per square kilometre of arable land is one of the highest in the world (World Bank 1995, p.374).

Nepal is largely an agricultural country, with 90 per cent of the population living in rural areas and also about the same proportion of persons employed in agriculture. The national income is derived for over 50 per cent from agriculture, which makes Nepal very dependent on agricultural activities (World Bank 1992). Over recent years, however, the share of agriculture has been declining very slowly but by world standards is still high (The Economic Intelligence 1991). To improve Nepal's economic position, the agricultural production and the export base need to be diversified, which now tends to be narrow and consists of a few primary products only. Diversification of the economy takes place to some extent, as the manufacturing and service sectors have expanded, but is still very limited.

Nepal is very dependent on its natural resources. Land is essential for crop cultivation, and to provide in the national food supply, while forests are essential for their supply of fuelwood and fodder. Nepal's natural resource endowment has come under increasing pressure in recent years. With a rapidly increasing population, the pressure on natural resources in Nepal has seriously increased. Depletion of soil has resulted in lower crop yields. The discrepancy of an increasing population and a stagnating or declining crop production, resulted in a decline in the per capita net foodgrain production and food shortage, which is perhaps the harshest problem. The food deficit problem faced by households has become an annual phenomenon, especially among small and marginal farmers. Although traditionally a food-exporting country, Nepal is on the verge of importing foodgrains to feed its rapidly growing population.

According to Raj Devkota (1998) there is a wide variety of environmental sustainability problems in Nepal, in particular the loss of forest, the loss of biodiversity, soil erosion, air pollution, water pollution and solid waste. The implementation of effective sustainability policy measures in this ecologically rich country is unfortunately impeded by the economically distressed situation in Nepal, which is reaching negative consequences for both the rural and the urban environmental quality. It is clear that agriculture plays a prominent role in sustainable development policies of Nepal. This also applies to the case study in our paper, the Bagmati region.

The Bagmati region

The Bagmati region is economically the main area in Nepal. It is geographically centrally sited and includes the capital city Kathmandu and the Kathmandu valley. The Bagmati region consists mainly of hills and mountainous areas and is subdivided into eight districts. It has a great diversity of landscape and types of soil, which influences land use. Though technical characteristics like these are of influence on the state of natural resources, they are not explicitly considered in this scenario analysis. This analysis is rather a policy scenario analysis for sustainable development.

Crop, livestock and agro-forestry are major components of the farming system in the Bagmati region, primarily undertaken for household consumption (Antoine and Sharma 1994). The main crops under cultivation in the Bagmati region are paddy (40% of total available land), maize (20%), potatoes and radish (below 10%). Some of these crops are seasonal so they are combined with other crops, which grow in another period. The choice of crop depends on the accessibility conditions of grounds and the size of the farm household. For example, smaller households tend to have a higher proportion of cropped area under maize in different accessible areas. Only a minority of farmers use fertilisers and although there are signs of a development of a more intensive cropping pattern with increased multi-cropping during the year, the extent to which farming technology has altered, is limited.

Besides cultivation, land is used to keep livestock which also supports cultivation of soil by providing fodder. Grounds with low accessibilities (high mountain areas) tend to have a higher proportion of grazing land for livestock than high accessible land, which are more used for crop cultivation. Agro-forestry is also a source of income, but more and more forests are chopped due to lack of fertile ground for crop cultivation and to provide in fuelwood supply. This causes serious deforestation and an increasing environmental pressure.

The rural population in Nepal depends primarily on the extraction of food and energy from renewable natural resources such as land, forests and water. The food and energy needs are increasing along with the population growth. Therefore, food deficits and poverty are closely related and further interlinked with the quality and quantity of land and forest resources. Food and energy are becoming more difficult to extract due to the degradation and depletion of renewable resources. A solution to the food and the energy problem is essential. Agriculture and forest development can therefore be seen as crucial factors for improving the rural economy and decreasing poverty and environmental degradation. In order to come up with solutions, a proper understanding of the interactions and interdependencies is necessary. Clearly, the greatest challenge facing developing countries with poor natural resources and rapidly increasing populations such as Nepal, is sustainable development.

To determine a well-integrated strategy, it is important to have a clear view to the problems of rapidly deteriorating resources and the impact on food and fodder supplies, which are crucial factors in life support in most developing countries (Banskota and Sharma 1995). For Nepal, two major environmental sustainability problems in the agricultural sector can be identified, deforestation and exhaustion of soil. The socio-economic dimension of sustainability shows that also three other sustainability problems can be identified, high population growth poverty and food deficits.

Biophysical aspects

Deforestation means a structural decrease of the forest resource. In Nepal, it occurs mainly due to the high population growth. To provide the increasing population with fuelwood and fodder, more and more wood needs to be chopped, resulting in severe deforestation. Besides the need for fuelwood and fodder, forests are chopped because of a lack of fertile agricultural land for crop cultivation. The growing rural population needs more land for cultivation to fulfil food demands. Wooded hill-tops have been cut down or severely depleted because of this. Deforestation rates vary on national level from 1 per cent a year in high mountainous areas and 1.44 per cent a year in hill areas. In the Bagmati region, 65 per cent of high mountainous areas is still forested, while in hill areas the percentage of forest resource severely has decreased to 13 per cent, which is far below sustainable agriculture.

Deforestation and land use intensification without conservation measures, lead to erosion and exhaustion of soil, and disrupts the normal hydrological cycle. Erosion and loss of agricultural land lead to another round of deforestation. Missing fodder and fertiliser lower the yield and this leads again to the extension of agriculture land and deforestation (Messerli et al. 1992).

Subsistence farming is the major occupation of more than 90 percent of the population in Nuwakot, one of the districts of the Bagmati region (Antoine and Sharma 1995). A lack of fertile soil encourages overexploitation of marginal grounds by farmers, in order to harvest the maximum for life support, which often is not enough. Grounds become severely exhausted and more fragile. Crop yields are decreasing and food deficits and poverty are increasing because of this.

Social aspects

The main social problems in the Bagmati region are high population growth, poverty and food deficits, which are strongly interlinked problems. Environmental pressure on soil is increasing, as peasants try to maximise the crop production to support in food supply for the growing population. This causes exhaustion of soil and decreases fertility. Instead of increasing the output, harvests are decreasing and food deficits arise.

Due to relatively high population growth also pressure on the carrying capacity of cropped soil increases. The annual growth rate of food production is not as high as the annual growth rate of population, which decreases food availability. As 90 per cent of the population is dependent on agriculture, a food deficit along with low incomes increases poverty.

Economic aspects

In Nepal, the income among the Nepalese population is low because of high unemployment in the rural sector but also due to low yields of rural production. Crop yields are often just enough for self support and only little is left to sell. Unemployment is high and means to generate employment in the agricultural sector appear to be fairly limited. Therefore, the rural population is often attracted to urban areas for off-farm employment and by the relatively higher economic growth in urban areas (the pull factor). The motivation for migration also stems from the growing hardships in rural areas where poverty is increasing (the push factor). Diminishing per capita agricultural land on account of population growth and the need to generate income by working outside the farm necessitates many, especially landless and marginal families, to get involved in off-farm activities (Antoine and Sharma 1995). Unfortunately, the off-farm activities often appear to be very limited. Given the inability of small farmers to produce sufficient food on very small and marginal plots of land, together with the lack of off-farm employment opportunities, these farmers are forced to borrow at high interest rates from informal sources, worsening their economic condition every year.

Related to poverty are major spatial and social inequalities in terms of access both to resources for production and to facilities for consumption. The problem of poverty has to be seen, among other causes, in the context of rural-urban imbalances. Nevertheless, for the vast majority of both peasants and urban workers in Nepal, the crisis which reflects the structural underdevelopment of the economy is persistent and chronic; the reproduction of deprivation and poverty, which is a function of the continuing underdevelopment of Nepal, manifests itself nationally as a crisis, and for the vast majority of the rural and urban population as constant hardship, uncertainty and desperation.

5. Three Policy Scenarios for the Bagmati region

Introduction

The Bagmati region and its agricultural sector can in principle develop in diierent directions. The range of possible policies which affect agriculture in the Bagmati region is sizeable. It is impossible to consider all thinkable policies and it would even not be useful, nor efficient. Instead, it is more useful and efficient to consider a few divergent policy directions and get a clear idea of differences and similarities among alternative futures with regard to sustainability. Three future options for Nepal are especially relevant. To evaluate these scenarios, the flag evaluation method is chosen as a decision-support method to analyse the scenarios on their degree of sustainability.

To evaluate different policy orientations, the use of scenario analysis enables a systematic way of scanning various uncertain future choice possibilities. A scenario is a possible image of future events, like a policy strategy to pursue (Hermanides and Nijkamp 1996). Scenario analysis can also be an important tool where long-term uncertainties are concerned. Uncertainty refers to situations where it is not possible to attach probabilities to the occurrence of events. The likelihood of their occurrence is neither known by the decision-maker nor by anyone else (Ellis 1993).

Especially three relevant policy directions are thinkable for Nepal. To concretise these directions, three scenarios are formulated according to a study done in Nepal (Banskota and Sharma 1995). Specific objectives of the study are to develop a systematic framework for assessing the effects of alternative policies on the economy, to carry out a policy evaluation and to provide general guidelines for policy actions.

The study done by Banskota and Sharma covered five rural districts of a total of eight of the Bagmati region. These five districts include Kabhrepalanchok (Kabhre), Sindhupalchok, Rasuwa, Dhading and Nuwakot. Our scenario analysis will focus on Dhadiig, since relevant data was available and the primarily agricultural activity is land cultivation. Also, this district is chosen as it is a hill area, which represents a good case for a study on overexploitation of natural resources.

Three scenarios can be formulated according to the study of Banskota and Sharma. First, the continuation of agriculture in the current approach without any policy interference. This is called the ***baseline scenario.*** The second scenario has a socio-economic priority. Reduction of the population growth should improve food security and decrease poverty in Nepal. This scenario is based on policy actions on the demand side of the economy and on the macro-economic level'. This scenario is called the ***demographic*** scenario. Third, fertilisers and irrigation should improve food security and decrease overexploited land use. Also, this scenario can decrease poverty but with a diierent

[1] This study does not include how the governmental interventions should be accomplished.

approach than the demographic scenario. This is called the *food security scenario* and is based on government interventions on the supply side of the economy and at the micro-economic level.

Baseline scenario

The first scenario is the baseline scenario, which includes a future development in the line of the current situation in Nepal and the Bagmati region, as described in Banskota and Sharma (1995). Future development under this scenario will not be very sustainable as will be explained below, due to high population growth. A growing population will create higher demands for production and consumption, which results in an unsustainable use of natural resources, such as soil and forests. Since the population growth surpasses the growth in net food production, the per capita availability of all food items in Dhading shows a declining trend over time under the baseline scenario. The increasing use of natural resources will affect Nepal's stock and quality of its resource base, which will likely cause environmental degradation.

Within the scope of this analysis, continuation of the current development includes a continuous *overexploitation of natural resources,* especially forests and cultivated land. Given the negative trend in productivity growth and a continuous deforestation, related to the high population growth the carrying capacity of the district in terms of food and natural resource products, particularly fuelwood, fodder and timber, shows a declining trend over time. Depleted soil causes for more deforestation. However, it does not improve food supply when more marginal grounds are being cultivated due to environmental degradation, resulting in declining productivity.

The socio-economic situation in Nepal can be characterised by *poverty and low incomes. As* the population growth rate exceeds the income growth rate, poverty will be increasing among Nepal's population especially among the rural population which includes over 90 per cent of Nepal's population, as yields will stagnate or decline and rural incomes will remain minimal. However, the main goal of the current policy is to support economic growth in order to cope with poverty. Poverty is thus expected to increase under the baseline scenario, while the initial policy goal, economic growth in order to decrease poverty, will not be achieved.

Since the agricultural sector is the main economic activity in Nepal, economic growth will not be very high when it is accomplished by an increase of the non-agricultural sector. Under the current state of technology and infrastructure, the performance of the agricultural sector, upon which the economy of the country depends, continues to remain fairly stagnant or to show signs of negative growth over the period considered. This explains the low economic growth, besides the small growth base of the non-agricultural sector (see Table 1).

BIOPHYSICAL DIMENSION:	high use of natural resources
SOCIAL DIMENSION:	high population growth and low food security
ECONOMIC DIMENSION:	low economic growth

Table 1. Overview of the baseline scenario according to the three dimensions of sustainability

Demographic scenario

The demographic scenario takes a socio-economic policy perspective. Its goal is to support socio-economic development in the future by means of a reduction in the population growth. A high population density and a high population growth rate decreases the average food supply, if food production is insufficient. As food production is stagnating or even declining due to soil exhaustion and lower soil fertility, food supply will decrease with an increasing population. This increases poverty and reduces the socio-economic state of many rural households.

The demographic scenario aims at a national reduction of population growth of 1 per cent from the level in 1993 over five years. Population growth is gradually reduced starting from 1993 and is increased annually to reach a total decrease of 1 per cent by 1998 (Banskota and Sharma 1995). For Dhading, the population growth in 1991 was about 1.5 1 per cent and relatively low compared to the national average of 2.3 per cent. Despite this relatively lower population growth, the economy of Dhading is fairly unsustainable, based on the developments under the baseline scenario. Thus, a population growth reduction policy was next examined for Dhadmg.

The population growth reduction policy is assumed to start in 1993 and to continue until 1998. Initially, only a small reduction of growth rate was envisaged and this was allowed to decrease each year till it would reach 0.605 per cent in 1998. This was made possible by reducing the annual growth rate by 0.2 per cent each year, beginning in 1993. Beyond 1998, the average growth is assumed to drive the population of Dhading.

BIOPHYSICAL DIMENSION:	high use of natural resources
SOCIAL DIMENSION:	population growth reduction and higher food security
ECONOMIC DIMENSION:	low economic growth

Table 2. Overview of the demographic scenario according to the three dimensions of sustainability

Food security scenario

An essential necessity of life is food. Food availability in developing countries such as Nepal is very minimal. Therefore, an important policy direction is one of increasing food security. The third scenario aims at increasing crop production and yields in order to secure food availability. Higher yields will increase rural incomes and stimulate economic growth. The food security scenario can thus be seen as a socio-economic policy towards economic growth and decreasing poverty.

The difference with the demographic scenario is that the food security scenario has a micro-economic approach (household level) from the supply side of the economy, while the demographic scenario is a macro-economic approach from the demand side of the economy. The food security scenario at household level is a bottom-up approach, in which economic growth is achieved by learning-by-doing. The rural households can increase the use of fertilisers to improve crop yields and achieve higher incomes. The demographic scenario is a top-down approach, which is often harder to implement, but more efficient than a bottom-up approach where control is less.

· Increasing crop production is to be achieved by increasing the use of fertilisers and irrigation projects. Data on irrigation is very limited in Banskota and Sharma's study. Data on the use of fertilisers is more available and will be used in our scenario analysis. The average use of fertilisers in the Bagmati region is 17 kilograms per hectare a year (Banskota and Sharma 1995). The use of fertilisers in Dhading is much lower, which is about 4 kilograms per hectare a year. Under the baseline scenario, the use of fertilisers would show a decreasing trend of 0.6 per cent a year. The food security scenario aims at an increase of the use of fertilisers on crops with 25 per cent in order to increase food productivity and food supply for the population. Demand for food does in general not change proportionately with the change in income. So, a higher food security can only be achieved by increasing food production. Therefore, increasing the use of fertilisers can be an essential policy direction for Nepal and the Dhading district.

Dhading is unable offer a sufficient supply of calories to meet the population's needs under the prevailing state of technology. Only about 74 per cent of the calorie requirement is being met under the baseline scenario. Under the food security scenario, this will be improved but for some food items, like fats and milk, Dhading will still have a supply shortage and is unlikely to meet the calorie requirements of its population.

As mentioned before, a higher food security may be accomplished by irrigation and the use of fertilisers. In terms of sustainability, the use of fertilisers and irrigation cannot be indefinite, as each natural resource, like soil, has a certain carrying capacity. Excessive use of fertilisers and irrigation for longer periods of time may cause irreversible damage to natural resources and is no longer sustainable. A well-considered use of fertilisers and irrigation is required under this policy scenario.

To increase the use of fertilisers, rural households need to be supported by governmental subsidies. The distribution of financial means shows the equity aspect of the food security scenario. Even if this scenario will decrease food shortages and poverty, there is no guarantee that higher fertiliser use will also reduce the pressure on the forests and soil of Dhading. The population will still need fuelwood and fodder and will continue using deforested land for cultivation. As mentioned before, higher fertiliser use does not necessarily decrease pressure on cultivated soil. The food security scenario will improve the socio-economic situation in Dhading but the environmental pressure will remain high. An overview of the main characteristics of the food security scenario is given below (see Table 3).

BIOPHYSICAL:	high use of natural resource
SOCIAL:	high population growth but higher food security
ECONOMIC:	higher economic growth

Table 3. Overview of the food security scenario according to the three dimensions of sustainability

6. Evaluation of Policy Scenarios for the Bagmati Region

For the district Dhading in the Bagmati region in Nepal, the following thirteen indicators have been developed according to the study of Banskota and Sharma. These thirteen indicators form the so-called working set of indicators. For each indicator, three CTVs have been determined, a CTVmin, a CTV and a CTVmax. Also, each of these indicators is uniquely assigned to a biophysical, social or economic class. These indicators and their assessed values are presented in the following table (see Table 4) and will now concisely be described.

INDICATOR	Type	CTVmin	CTV	CTVmax
BIOPHYSICAL				
1. Pesticide use per area (kg/ha)	B	15	20	25
2. Fuelwood supply as % of demand	G	70	80	100
3. Area of forest resource (%)	G	40	50	65
4. Deforestation rate	B	0.3	0.4	0.5
5. Annual % growth of total cultivated area	B	0.5	0.75	1.0
6. Annual % of forest/cultivated area	B	0.5	1.0	1.5
7. Carrying capacity of agricultural land (adult/ha)	G	6.0	6.5	7.0
SOCIAL				
8. Annual % yield growth of maize (kg/ha)	G	0	0.1	0.2
9. Calorie supply as % of demand	G	75	85	95
1 0.Annual % population growth	B	0.3	1.0	1.5
ECONOMIC				
11.Unemployment	B	5	10	15
12. Annual % growth of real income	G	1.0	1.5	2.0
13 Annual % per capita growth of food export	G	-0.5	5	15

Type: B= Bad (i.e. the less the better)
G= Good (i.e. the more the better)

Table 4. Values of CTVmin, CTV and CTVmax (derived from Banskota and Sharma 1995)

Biophysical indicators

(1) The application of chemical fertilisers in Dhadiig is very low, compared to averages in the Bagmati region. A farmer in the hill district Dhading uses about 4 kilograms per hectare annually, while the average in the Bagmati region is about 17 kilograms per hectare. The use of fertiliser on cultivated grounds may be increased carefully to stimulate crop yield. However, excessive use of fertilisers may endanger soil sustainability, as the level exceeds the quantity a certain area can take up and causes problems to soil and ground water.

(2) Fuelwood is essential in Nepal, as it is the main source of energy. As the population growth exceeds the growth of forests, fuelwood supply as a % of the demand for fuelwood is seriously decreasing.

(3) Due to deforestation, the area of forest resource is decreasing rapidly.

(4) This indicator shows the rate of chopped forests annually. The rate has been increasing during the last decades, but needs to decrease to prevent irreversible damage.

(5) Dhading showed an increasing growth rate of the total cultivated area of about six per cent per annum during the 1970s. During the last years, cropped areas have increased, but less rapidly at about 0.16 per cent.

(6) The ratio of forest/cultivated area shows that forests are decreasing in relation to cultivated areas.

(7) This indicator shows how many persons an area of agricultural land is able to support in calorie supply without depletion of the ground. The number of people per hectare of cultivated land under the baseline scenario is 7.4, while in Dhading the carrying capacity per hectare is 5.3 persons (Banskota and Sharma 1995, p.252). The carrying capacity of cropland is declining marginally over time because of a negative trend in calorie supply as a result of the declining trend in crop productivity.

Social indicators

(8) Maize is, together with rice, the main food crop in Nepal. Due to decreasing soil fertility, yields are decreasing. Top soil is overexploited and erosion occurs. Fertilisers may increase crop yields, but must not be used excessively.

(9) Calorie supply as a percentage of calorie demand shows the food availability in Dhadiig. Despite the surplus in cereals, meat and vegetables, Dhadiig shows a shortage of calorie supply under the baseline scenario, due to a decreasing soil fertility and lower crop yields.

(10) Nepal's annual population growth between 1989 and 1994 was around 2.4 per cent. Compared to a growth rate of 1.8% in South Asia, the growth rate in Nepal is relatively high (World Bank 1996). In Dhading the population growth rate is lower at 1.5 per cent, but the population of the district is high in relation to the economic base, and it is believed that more and more people are falling below the poverty lime.

Economic indicators

(11) Unemployment rate is the rate of labour demand to labour supply. During 1991 over 85 per cent of the labour force in the district was gainfully employed, with about two-third employed in the agricultural sector. Since the projected labour supply increases at a higher rate than the labour use rate (due to increasing population growth), the unemployment rate increases marginally over time.

(12) The per capita nominal income for Dhadiig in 1991 was 930 Rs (Rupees), which is fair compared to other rural districts of the Bagmati region. However, income growth is still at a low level of 2.8 per cent (World Bank 1995, p.375).

(13) The extent of food items exported or imported in the district is determined by the magnitude of food surplus or deficit based on food demand and supply. As the surplus in cereals, meat and vegetables is large enough to compensate for the magnitude of deficit in other food items, Dhading is a net exporter of food.

Flag evaluation

Combining the CTVs of thirteen indicators and the flag evaluation model, different indicator outcomes have been determined for the three scenarios designed for Dhading. Table 5 shows the indicator values for each scenario as used in the flag evaluation model.

The evaluation shows that actually all scenarios are unsustainable, as each scenario has some black flags for certain indicator values. The baseline and the demographic scenarios are the most u&stainable ones; not only do they give rise to 5 black flags, but these flags also appear in all three areas of sustainability: biophysical, social and economic.

The overall performance under the baseline scenario is apparently the worst of the three. Like the demographic scenario it accounts for 5 black flags and 3 red flags, whereas the demographic scenario has 5 black flags, but no red flags. The food security scenario shows a slightly better prospect than the baseline scenario, with 3 black flags and 4 red ones. Of course, it needs a more thorough analysis than just a number of flags, to determine the degree of sustainability for each scenario and to be able to compare the three scenarios with each other.

INDICATOR	Base	Demographic	Food
BIOPHYSICAL			
1. Pesticide use per area	4	4	5
2. Fuelwood supply as % of demand	89	92	89
3. Area of forest resource	32.66	32.73	33.04
4. Annual deforestation rate	0.48	0.34	0.48
5. Annual % growth of total cultivated area	0.157	0.111	0.018
6. Annual % decrease of forest/cultivated area	0.710	0.498	0.643
7. Carrying capacity of agricultural land	5.27	5.26	5.62
SOCIAL			
8. Annual % crop yield growth of maize	-0.2	-0.2	0.15
9. Calorie supply as % of demand	71	73	90
1 0.Annual % population growth	1.5	0.605	1.5
ECONOMIC			
11.Unemployment rate	20	18	16
12.Annual % growth of real income	1.321	1.841	1.129
13 Annual growth of per capita food export	6.729	5.659	10.038

Table 5. Quantitative impact matrix for three scenarios for agricultural development in Dhading (Banskota and Sharma 1995)

Baseline scenario

Under the baseline scenario, the carrying capacity of agricultural land falls to a level far below sustainable agriculture, which on short term has to be changed. If the carrying capacity of an area of land decreases, rural households need more land to fulfil their food demands. Indicator 3 also shows a black flag under the baseline scenario, which refers to a serious decline in the forest resource in the Bagmati region.

Also the social indicators, annual crop yield growth of maize and the calorie supply, turn out extremely unsustainable under the current developments of the baseline scenario. Carrying capacity of land is decreasing, which is most likely interlinked with the decline of crop yields and a low calorie supply.

The economic indicator. unemployment rate, is far below sustainability levels under the baseline scenario. The high population growth increases the demand for labour. Unemployment and decreasing crop yields cause lower incomes. Food imports need to fill up the lack of national food deficit.

The overall performance under the baseline scenario is far below sustainable and needs a quick change of policy.

Demographic scenario

The demographic scenario can be seen as more sustainable than the developments under the baseline scenario. The emphasis on population growth reduction as the main policy goal, has a positive effect on this particular indicator, as well as on the deforestation rate, the cultivated/forested area ratio and the growth rate of income. The flag evaluation outcome shows 5 black flags, 5 yellow, 3 green and no red flags. Compared to 5 black, 3 red, 3 yellow and 2 green under the baseline scenario, the demographic scenario seems more sustainable.

The biophysical indicators show the same outcome as the baseline scenario, except for the deforestation rate, which has a yellow flag, while under the baseline scenario this is a red flag. A lower population growth will decrease the pressure on forest resources, as less fuelwood is needed and the need for more new land for cultivation will decrease. However, this is more a long-term effect, while on the short term rural households still try to extend their production to increase food supply and incomes.

The only difference between the baseline scenario and the demographic scenario in their social performance is the population growth rate which is reduced under this scenario. A lower growth rate of population in Nepal will decrease environmental pressure on natural resources.

Finally, the economic performance under the demographic scenario is slightly better than under the baseline scenario. The demographic scenario counts for 1 black and 2 yellow flags, while baseline developments count for 1 black, 1 red and 1 yellow flag. The red flag under the baseline scenario is given to the value of the growth rate of income, which is less sustainable than under future developments with a population growth rate reduction.

The overall performance of a demographic scenario, which is characterised by a population growth rate reduction, is slightly better than under the current developments in the Bagmati region of Nepal. However, the performance is still far from sustainable.

Food security scenario

The food security scenario stands for an increase of the use of fertilisers on cropped soil for 25 per cent. Higher use of fertilisers will increase crop production and give higher incomes for rural households.

The food security scenario is slightly more sustainable than the baseline scenario. It counts for 3 black flags, 4 red, 4 yellow and 2 green flags. Current developments count for 5 black flags, which present a very unsustainable situation, where further growth is a great risk to Nepal's future. A food security scenario would be more sustainable as it counts less black flags.

The biophysical performance under the third scenario is like the baseline scenario. Both scenarios show the same flag counts.

Social indicator outcomes of the food security scenario show that it counts for the most sustainable future concerning the social dimension of sustainability. The indicator outcomes show that still reverse trends are needed, but the social situation is not as dangerous as under the demographic or baseline scenario.

Finally, the economic outcome of the flag evaluation shows that a food security scenario is as unsustainable as under the baseline scenario. Especially the unemployment rate is far below sustainable, due to the majority of the population living in the rural areas and being dependent on the agricultural sector, but unable to find work there.

The overall performance of the food security scenario is, socially seen, more sustainable than the other development scenarios. However, the degree of sustainability of the overall developments under the third scenario is still unsustainable.

Future policy actions

If the results of the three scenarios for Nepal's Bagmati region are put together and mutually compared, a qualitative impact assessment can be made. Table 6 shows the outcome of this assessment in a so-called impact matrix for the three scenarios and the three dimensions of sustainability. Of course, a certain arbitrariness may enter the analysis for qualitative forms.

Dimension / Scenario	Biophysical performance	Social performance	Economic performance
Baseline scenario		--	
Demographic scenario	+/-		+/-
Food security scenario		+	

Legend: ++ = substantial increase
+ = slight increase
+/- = neither increase nor decrease
- = slight decrease
-- = substantial decrease

Table 6. Qualitative impact matrix for three scenarios for agricultural development in the Bagmati region in Nepal

The matrix shows that baseline developments are far below sustainable, that further growth under this scenario should drastically be encouraged, and that policy actions need to be taken. However, two other policy approaches were analysed and they proved to be unsustainable as well. The only positive exception, is the social performance under a food security scenario, which shows no black flags and which especially performs well in the social dimension. Obviously, an increasing use of fertilisers, which will increase crop production, will have a positive effect on crop yields and food supply in the region. A population growth reduction will improve biophysical and economic performance and in time probably also social performance.

However, none of these scenarios shows an overall sustainable development. A more sustainable performance in one particular dimension of sustainable development is not overall sustainable. It takes a more integrated approach of various policy actions to select a sustainable development portfolio. A meaningful direction may be found, if population growth is reduced together with a higher use of fertilisers in order to increase food production. For a more integrated approach policy measures on both the supply and the demand side of the economy are needed. Action from both sides will be more effective, than ad hoc and single policy measures.

Recommendations

Like many other developing countries, Nepal is very dependent on its natural resources. However, the increasing use of those resources puts serious pressure to the environmental quality in Nepal and even causes environmental depletion. The combination of increasing intensity of agriculture on the more environmentally robust land and rising incomes make it possible and indeed desirable for individual farmers to withdraw the environmentally fragile land from arable agriculture.

Agro-ecosystem - one of the biggest ecosystems modified by people to produce food, fiber and other products - has recently become a focal point of environmental problems in Nepal for many reasons. Environmental problems in Nepal stem mainly from natural resource degradation which is closely linked to agricultural activities. Therefore, a careful consideration of the environment is of critical importance for an acceleration of agricultural growth in Nepal.

The flag evaluation model as shown in our case study of Nepal, offers a systematic simple framework for a much more complex world, especially when only small numbers of indicators are used in a so-called working set or core set of indicators. Clearly, a balance needs to be found between too few indicators, which endangers the link with the complex reality, and too many indicators, endangering the efficiency of decision support models such as the flag model. However, the use of such decision support models and indicators do provide strategic information on which complex decisions can be based, especially concerning such an ambiguous concept as sustainable development.

7. Retrospect and Prospect

The goal of sustainable agricultural development is essentially based on a portfolio of different and often conflicting indicators, which have to be traded-off against each other. This normally implies a kind of multi-criteria evaluation, but in the case of sustainable development policy a goal-oriented frame of reference is needed. In the present paper the departure of our analysis has been the notion of critical threshold values, based on a range of scientific views of experts on the critical loads or carrying capacity in relation to agricultural production in a certain area. These critical threshold values - once accepted, respected and put in policy practice - would then ensure a situation of strong sustainability. Clearly, also trade-offs among critical threshold values might be envisaged, but that would erode the meaning of 'critical'. It ought to be recognised that the agricultural sector goes at a world-wide level through a drastic change process, as is witnessed by our Nepal case study. We observe specialisation and intensification on the one hand, and extensification and diversification on the other hand. Consequently, there is not an unambiguous and uniform panacea for sustainable agricultural development. There is a wide range of farming practices each situated in site-specific localities. Hence, it seems to be plausible to direct policy initiatives towards the regional level, as was illustrated in our case study. Seen from this perspective, there is a vast research agenda for agricultural sustainability analysis. Elements of this agenda are:

- the development of a better assessment system through which the consequences of human action and government intervention for sustainable development in the agricultural sector can be more properly traced;
- the search for key valued attributes of regional sustainable agricultural development in relation to land use and land cover in order to better identify policy relevant indicators;
- the use of GIS related modelling techniques which are able to link decision support models of a multi-criteria nature to site-specific and geographically detailed conditions;
- the search for transferable research findings from a series of case studies on similar sustainability issues (by using meta-analytic methods) in order to create a learning device for policy-making.

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